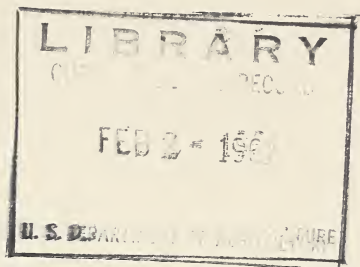


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EFFECT OF Cotton Defoliation
on Yield and Quality ^{+L3a}

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Production Research Report No. 46

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Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

In cooperation with the
Arkansas, Mississippi, Missouri, and Oklahoma
Agricultural Experiment Stations

Foreword

The delayed publication of results from these experiments conducted during 1948, 1949, and 1950 is in need of some explanation. Actually the results were made public promptly at the Beltwide Cotton Defoliation Conferences, and the data were partly contained in the processed Proceedings of the Conferences held in 1949, 1950, and 1951. But distribution of these Proceedings was then limited principally to those who attended the Conferences.

The more than fivefold increase in use of cotton harvest-aid chemicals since these experiments were conducted, however, has created a new need for giving publicity to the results. The data are particularly needed at the present time (1960) because the amazing increase in cotton yields that has occurred during the past 8 years (279.9 pounds per acre in 1952 as compared to 462 pounds in 1959) has been produced on larger, leafier, and later plants. This large bulk of late-growth leaves makes the successful use of defoliants difficult. At the same time it challenges the grower to utilize all knowledge available if he is to apply defoliants in a manner that will insure preservation of both yield and quality of cotton lint and seed. The data presented here, together with their interpretation, should contribute much to the development of reliable guides for the successful timing of defoliant applications on cotton.

Acknowledgments

This report presents the results of a cooperative cotton defoliation study conducted under the sponsorship of the Beltwide Cotton Defoliation Conference. In addition to the authors, the research personnel participating in these investigations included :

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Effect of Cotton Defoliation on Yield and Quality

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Leaves are a nuisance when the cotton crop is fully mature and the open bolls are ready to harvest. Removal or desiccation of these leaves with harvest-aid chemicals does no harm to the crop already matured and in many instances the treatment is beneficial, particularly where machine harvesting is contemplated. When used properly either defoliation or desiccation will permit more rapid drying and opening of mature bolls, increase efficiency of harvesting, decrease damage due to weathering, and, as a result of these benefits, will usually preserve quality of cotton lint and seed.

Often, however, a portion of the cotton crop is still immature at the time when the grower would otherwise realize the greatest benefit from application of harvest-aid chemicals. This is particularly true when high-yielding plants are large, late, and leafy; where the impending cool weather reduces defoliation efficiency; and where early fall rains increase deterioration of seed and fiber in the mature and already opened bolls. Under such conditions it is important for the grower to be able to evaluate accurately the potential damage to yield and quality that might result from premature applications of cotton harvest-aid chemicals.

The research reported in this bulletin evaluates the potential loss in yield and quality of cotton that might be expected when defoliant chemicals are applied during the different stages of boll development and crop maturity. The investigations were initiated on a regional and cooperative basis so that the accumulation of data from such tests, conducted at different locations in the Cotton Belt, would provide information for the development of guides for applying defoliant and desiccant sprays and dusts.

REVIEW OF LITERATURE

Ludwig's (10)¹ studies on the effects of time of leaf removal were conducted in 1925, at Clemson, S.C., prior to the discovery that chemicals could be used effectively to defoliate cotton plants (1, 8). Ludwig removed leaves by hand to simulate attacks by the cotton leaf worm *Alabama argillaceae* Hubm., in order to determine the extent of damage to yield and quality that could be expected from serious infestations, which often completely defoliated cotton plants. His earliest defoliation, when first bolls were opening, caused weakening of fibers, a 50 percent reduction in yield, a 30 percent reduction in boll

¹ Italic numbers in parentheses refer to Literature Cited, p. 11.

weight, and a significant increase in time required for young bolls (13 to 17 days old at time of defoliation) to open. Removal of leaves when half the bolls were open caused 6 percent reduction in yield and 11 percent loss in boll weight.

After the discovery that calcium cyanamide dust would efficiently defoliate mature cotton plants, Hall and Harrell (8) conducted tests at Florence, S.C. (beginning in 1938), to determine if chemical defoliation could be used as an aid to the control of boll rots. Although these workers presented no data regarding exact time of defoliation they concluded that ". . . bolls should be well developed before defoliation takes place to avoid injury to staple and seed."

The spindle-type mechanical cottonpicker, in commercial production by 1941, depended to a large extent on efficiency of green-leaf removal for its successful operation. This need, coupled with the discovery by Dunnam and coworkers (5) that defoliation with calcium cyanamide caused boll weevils to leave treated fields, motivated the beginning of a series of experiments at the Delta station in Mississippi. The purpose of the studies was to learn not only how to apply defoliant efficiently but also to learn if and how the defoliant might affect yields or quality of lint and seed. It was reported in these studies (6, 7) that chemical defoliation at the time the youngest bolls were 20 days old resulted in weak fibers and possible loss in yield, but if the youngest bolls were 30 days or more old no deleterious effect was found in the fiber.

After the research discussed in this report was initiated, several other studies of the effect of premature defoliation on yield and quality of cotton were published (16). Walhood (19) tagged bolls daily for a period of 27 days during the active fruit-setting period at Shafter, Calif. One series of plots was defoliated and another series was desiccated on the same day when bolls were from 25 to 51 days old. Bolls from these treatments were compared with bolls of equal age in untreated check plots. Results indicated that there was a critical point with regard to effect of age of boll when treated. Bolls that were 41 days or older when treated had a lengthened boll period, whereas bolls less than 40 days opened faster. Defoliation or desiccation of foliage of plants with 41-day and older bolls caused no significant change in boll weight and seed weight, but treatment when bolls were between 32 and 41 days old caused up to 18 percent reduction in boll weight and seed weight, and treatment when bolls were 25 to 31 days old caused up to 44 percent reduction. Walhood (19) found that desiccation, which curtails growth more quickly than defoliation, caused slightly greater reductions in boll and seed weight than did defoliation when bolls were less than 42 days old at time of application. Later (1959), under California conditions, Walhood (20) showed that where visible leaf injury is usually evident 2 to 3 days after application of a defoliant, immature bolls continue to develop about 5 days after application. When leaves were dried immediately with desiccant, however, the immature bolls continued to develop only 2 or 3 days after application.

In their studies with bottom defoliation in Arizona, Brown (2) and Brown and Hyer (5) evaluated the damage that might occur to cotton when defoliant is applied at a too early stage of growth or applied too close to the top of still maturing plants. They found

that fiber from bolls less than 35 days of age at time of defoliation was shorter and usually finer than fiber from mature bolls. Germination of seed was reduced and yields were usually reduced in these tests when even a small percentage of the bolls in the defoliated portion of the plants were immature—under 35 days of age.

In their 3-year study of the economics of defoliation in the Mississippi Delta, Crowe and Carns (4) found that defoliation when 50 to 80 percent of the bolls were open reduced the average yield about 3 percent and slightly reduced foreign matter content of seed cotton (from 2.4 percent to 1.7 percent). The effect on length, strength, and fineness of fibers was negligible, however, and earliness of harvest was unaffected in these Mississippi studies.

MATERIALS AND METHODS

Experimental Design

A different experimental plan for time-of-defoliation treatments and harvests was used in the first year, as compared to the second and third years. To facilitate description better, the first-year tests (1948) are hereinafter referred to as series A, and the 1949 and 1950 tests are designated as series B, first and second year, respectively.

Series A tests were designed for six time-of-defoliation treatments, in four replicate randomized blocks. Defoliants were applied in relation to height of bloom² on a 6-day interval basis as follows:

- Treatment 1.—Defoliant applied 17 days after height of bloom.
- Treatment 2.—Defoliant applied 23 days after height of bloom.
- Treatment 3.—Defoliant applied 29 days after height of bloom.
- Treatment 4.—Defoliant applied 35 days after height of bloom.
- Treatment 5.—Defoliant applied 41 days after height of bloom.
- Treatment 6.—Check, not defoliated.

In each test all open blooms were tagged on the day estimated as height of bloom. The early (bottom crop) harvest consisted of all cotton, other than in tagged bolls, that was open and ready to pick on the day when the bolls tagged at height of bloom were fully open in the untreated plots. The tagged bolls were next harvested separately. The remaining cotton in each plot was harvested when all bolls were open and was designated as the late (top crop) harvest.

At Marianna, Ark.; Stoneville, Miss.; and Sikeston, Mo., series A tests were conducted exactly as planned. At the fourth station, Sacaton, Ariz., the test was conducted according to plan except that half of each treatment plot received an early last irrigation and the remaining half a late last irrigation. A minimum plot size of 4 rows, 100 feet long, with only the center 2 rows treated and evaluated for harvest and other records, was planted for each treatment.

Series B tests were designed for four time-of-defoliation treatments, replicated four times in a randomized block design. Four harvests

² Height of bloom was estimated as that time when there was the highest daily production of open flowers per acre, just before the start of a consistent and progressive decrease in blooming rate.

were designated for each plot, with both treatment and harvest determined in relation to time of cutout,³ as follows:

Treatment 1.—Defoliants applied 15 days after cutout.

Treatment 2.—Defoliants applied 23 days after cutout.

Treatment 3.—Defoliants applied 31 days after cutout.

Treatment 4.—Check, not defoliated.

Harvest 1.—All cotton open 15 days after cutout.

Harvest 2.—All cotton opening between 15 and 23 days after cutout.

Harvest 3.—All cotton opening between 23 and 31 days after cutout.

Harvest 4.—All cotton opening after the 31st day after cutout.

On the designated days, cotton was harvested before the defoliants were applied.

Series B tests were conducted as described at Marianna, Ark.; Stoneville, Miss.; and Sikeston, Mo., the first year (1949) as well as at Chickasha, Okla.; and at Sikeston, Mo., the second year (1950). At Sacaton, Ariz., the second treatment (23 days after cutout) was omitted in both years. Also at Sacaton, each treated plot was split; one-half receiving a strong, desiccant-type defoliant, the other half a mild defoliant—one which causes leaves to shed without excessive burning and rapid drying.

Experimental Procedures

Choice of varieties, methods of culture, defoliant chemical, and rate of application were optional in all tests. It was stipulated only that in each test a locally adapted variety be grown according to local recommendations for culture and that the plants be defoliated according to the best locally recommended practice. Varieties and defoliants often differed from one test to the next. The defoliant used early in the season was often different from the one used later, even at the same location.

Except where weather conditions prohibited, applications of defoliants and harvests (other than the final harvest) were made on predesignated days and the weight of seed cotton obtained per plot was recorded in the field. The cotton was then dried and stored until ginned—usually on a small experimental saw gin.

Measurements

When harvested samples were large enough, the following lint and seed properties were measured for each replicate plot sample.

Fiber properties were measured by standardized (9) procedures at the U.S. Cotton Fiber Laboratory, Knoxville, Tenn. *Length* was measured on the Fibrograph and expressed as upper half mean length (U.H.M.) in inches. *Strength* was measured on the Pressley Strength Tester at "O" gage and expressed in terms of the arbitrary scale, as Pressley Index. *Fineness* was measured by the Arealometer and expressed in terms of surface area ($\text{mm.}^2/\text{mm.}^3$).

³ Cutout is designated as that time when both blooming and vegetative growth cease—often abruptly. It may occur a few days after height of bloom or much later, and in some instances it is a tapering off rather than a strict cutout.

Seed properties measured were germination, oil content, and protein content.⁴ Germination was measured at Sacaton, Ariz., for all samples from series A tests and by commercial analysts for the series B tests. Standard procedures for germination were used by both (18). *Oil* and *ammonia* content of cottonseed were measured by commercial analysts following official National Cottonseed Products Association procedures (11). Oil and protein (ammonia) content are thus expressed as percentage content of the fuzzy cottonseed on a 10-percent moisture content basis. As about 2 pounds of seed are required for the official seed composition test, there were instances where samples were too small to permit measurements of either oil or protein.

Spinning performance of samples from all tests was measured at the College Station, Tex., spinning laboratory through cooperation with the U.S. Agricultural Marketing Service.

Yield was measured as pounds of seed cotton per plot per harvest.

Statistical Analyses

Data from series A tests were subjected to analysis of variance (13) for each of the three separate harvests. Analysis of variance of data from series B tests was performed on the combined data for all harvests; a split-plot analysis was used, wherein variability due to harvests was considered equivalent to split-plot information and that due to treatments equivalent to main-plot information. In tabulating yield and other data from series B tests the results are not shown, except for check plots, unless defoliation was applied prior to the harvest under consideration. Variance analysis, however, was performed on the complete data; that is, using data from all replicate plots at all harvests.

In many instances the harvested samples were too small for all seed and fiber property measurements; in these instances, samples of replicates were pooled to form samples large enough to measure, or, in other cases, eliminating the measurement.

EXPERIMENTAL RESULTS

Fiber Properties

Length.—The upper half mean length of cotton fibers was not significantly altered by any defoliation application utilized in the 11 tests conducted over a 3-year period (tables 1 and 2, appendix). Although there was a tendency for the earliest applications to cause shortening of the latest harvested cotton at many locations, there were also some reversals. For example, there were increases in fiber length in the late (harvest No. 4) cotton from the series B tests conducted at Marianna, Ark., and Chickasha, Okla. (table 2).

Strength.—The strength of cotton fibers, as indicated by the Pressley Index, was influenced in a variable manner by premature defoliant applications (tables 3 and 4). In no case were the fibers

⁴ Although most of the nitrogen content of cottonseed is in the proteinaceous state, official analysts measure and express the nitrogen content of cottonseed as ammonia. To convert to protein, multiply by 5.13.

significantly weakened. On the other hand, significantly stronger fibers resulted from premature defoliation at Marianna, Ark., Stoneville, Miss., and Sikeston, Mo. (table 3). Obviously, variation in Pressley Strength of fibers was influenced in these studies by other factors—perhaps variety and maturation environment—as well as by premature defoliation.

Fineness.—In 6 of 10 tests, fiber fineness was significantly increased by premature defoliation (tables 5 and 6). In most instances only the earliest applications (17 days after height of bloom for series A or 15 days after cutout for series B tests) caused a significant increase in fiber fineness. Also, in most instances the change was greatest in the late-harvested cotton. In a few tests, however, defoliant applied as late as 29 days after height of bloom caused significantly finer fibers to be developed. At one location, Marianna, Ark., even the early-harvested cotton was significantly finer where plants were defoliated 29 days after height of bloom (table 5).

From all 10 tests it is apparent that defoliation later than 29 days after height of bloom or 23 days after cutout will not be expected to cause significant increase in fiber fineness. However, the non-significant trend for even later treatments (35 days after height of bloom and 31 days after cutout) to be associated with some degree of fiber fineness shows that there may be some danger of causing finer fibers by almost any premature application of defoliant.

Seed Properties

Germination.—Viability of cottonseed was significantly lowered by premature defoliation treatments in only 4 of the 11 tests reported (tables 7 and 8). The earliest defoliation applications caused the more serious losses in viability and, as was the case with fiber properties, the significant reductions in germination were mostly in seed from the late-harvested cotton (tables 7 and 8).

Oil content.—Reductions in oil content of cottonseed associated with premature defoliation were found significant in 7 of the 11 tests (tables 9 and 10). In the majority of these tests wherein the reductions were found statistically significant, the earliest treatment, as well as several later treatments, markedly lowered oil content of seed. In fact, these results indicate strongly that any defoliant application made earlier than 32 days after cutout or 36 days after height of bloom potentially could cause significant reduction in oil content of seed. Oil content thus seems to be one of the most reliable indicators of deleterious effects of premature defoliation of cotton.

Protein content.—When measured as ammonia⁵ and so evaluated statistically, no significant changes in protein content of cottonseed were associated with premature defoliation. In other words, specific and constant change in protein content of seed in this study could only be directly attributable to variety or location influences.

Spinning Performance

Skein strength of yarns.—Skein strength was not found to be consistently altered by premature defoliant applications. In the series

⁵ To convert ammonia values to protein, multiply by 5.13.

A tests (table 11), however, there was little expectancy of obtaining large induced variation, as the early- (usually unaffected) and late-harvested cottons were blended to form the spinning samples. But even in the series B tests (tables 12 and 16), where the effects of defoliation are shown separately for the early- and the late-harvested cotton, there is no consistent change that can be associated with premature defoliation. Obviously, the significant differences in fiber strength (table 4) had little influence on the skein strength of yarns spun from these fibers. Thus, premature defoliation as applied in these studies did not contribute directly to variation in skein strength of yarns.

Yarn appearance grade.—The appearance grade of yarns was not consistently lowered by defoliation when tests are viewed on a total-crop basis, particularly in the blended samples from series A studies (table 11). If, however, only the effects on late-harvested cotton in series B studies (tables 12 to 16) are examined, a distinct trend toward lowering of yarn appearance grade is noted. Although this trend is not consistent through all 11 tests, it would be well to realize that premature defoliation could at times seriously reduce yarn appearance grade.

Picker and card waste.—Picker and card waste also shows little overall effect of premature defoliation. In the series B studies, however, there is a distinct trend toward increased picker and card waste of the early-defoliated, late-harvested cotton (tables 12 to 16).

Neps per 100 inches of card web.—Neps (tables 11 to 16) were rather consistently increased by early defoliation. Again, it is primarily the late-harvested cotton that is dominantly changed. Since there has been shown a close correlation between percentage of immature, thin-walled fibers in cotton and the nep content of yarns (12), it is not unexpected to find that defoliation treatments that make fibers finer also cause neps in the yarns spun from such cotton.

Yield of Seed Cotton

Significant reductions in total yield were obtained in four of the nine tests in which yield was measured (tables 17 to 22). In the series A test at Sikeston, Mo. (table 17), there was a significant reduction in yield associated with defoliation at both 17 and 23 days after height of bloom. In the series B tests the only significant yield reductions were caused by defoliating 15 days after cutout at Sacaton, Ariz., the first year (table 18), and at Sikeston, Mo., in both years (table 21). Here (tables 18 and 21) it should be emphasized that significance of yield reductions is primarily associated with a much reduced late harvest in the early-defoliated plots. In fact, at some of the locations the early defoliation markedly increased the yield of cotton that was open and ready to harvest at the early-harvest dates. The overall effect of premature defoliation on yield was shown to depend primarily on how much of the expected crop was immature at time of first applications of defoliant.

DISCUSSION

Defoliation of cotton plants when the entire crop is mature will usually tend to increase the harvestable yield of high quality lint and

seed; particularly where the application prevents deterioration, enhances earliness, and improves machine harvesting efficiency (1, 4, 6). Except where use, or misuse, of harvest-aid chemicals may cause slightly more dry leaf trash to be in the harvested cotton, there is seldom any deleterious effect expected from removing or drying the leaves, provided that the entire crop is mature. It is only in those cases where a portion of the crop is immature that any loss in yield and quality should be expected.

In this regional investigation the benefits of using chemicals to aid in the harvest of fully mature cotton have not been specifically evaluated. It was rather the purpose of these studies to determine how premature defoliation affects yields and quality of lint and seed. In order to understand thoroughly how such premature removal of leaves may influence yields and quality of lint, defoliation-induced changes are compared with the normal-time sequence of cotton blooming and boll setting and of cotton fiber and seed development. A brief, generalized outline⁶ of normal development follows:

1. Blooms are produced and bolls set over a long period—3 to 4 weeks for determinate varieties in short seasons and 6 weeks or more for indeterminate varieties at long-season locations.

2. Early-bloom set is usually high, but total seasonal averages are seldom more than 40 percent.

3. Bolls are full grown externally within 20 to 25 days, but they are not mature until 45 to 65 days of age, with the exact time dependent upon both variety and climate.

4. The critical period of fiber elongation is within the first 16 to 20 days, usually the first 18 days.

5. After fiber elongation ceases—about 18 days—fiber thickening begins and continues steadily until the boll is nearly mature.

6. Cottonseed is full size externally within about 20 days, but the embryo (kernel) does not develop rapidly until later—between the 20th and 45th days.

7. The critical period for rapid accumulation of oil in the kernel is between the 20th and 45th days, but protein usually accumulates at a slower rate than oil and over a longer period.

The foregoing outline of cotton boll, fiber, and seed development provides a basis for anticipating many of the alterations found associated with premature defoliation in these studies. But there are several instances of unpredictable variability. For example, when the deviations from normal development are tabulated as trends (table 23), the Pressley strength of cotton fibers was found significantly increased by premature defoliation in two tests. In the other nine tests the nonsignificant increases and decreases were about equal. When skein strength of the yarns spun from these fibers is examined, no consistent differences were found associated with these premature applications of defoliant (table 23). A partial explanation of this discrepancy is that Pressley strength of cotton fibers is only one of several factors that influence skein strength of yarns (17).

When the combined results from these 11 tests are viewed in terms of trends (table 23), it is found that the most consistent, and proportionately the largest, influences of defoliation-induced immaturity are reflected in the increased fineness of fibers and the decreased oil

⁶ Based on information presented in "The Cotton Plant: How It Grows and Why Its Growth Varies," by W. H. Tharp (15).

content of seed. In all 11 tests fineness was increased and oil content decreased, with the differences found significant in over half the tests. Next in importance is germination of seed. Viability was found lowered in most tests, and differences were significant in four, or slightly less than half the tests.

Most fibers were shortened by premature leaf removal (table 23), but the effect is neither consistent nor the differences significant. This is apparently contrary to prediction, as based on the time sequence of fiber development. That is, a 15-day boll should have potentially shorter fibers if development were stopped at this 15-day point. However, development undoubtedly was stopped later because, even where leaves are dropped immediately or killed outright by treatment, boll components are found to develop several days longer (20). Then too, most defoliant treatments do not cause effective leaf drop for 3 to 5 days following application. Hence, fiber development was not interrupted until 3 to 5 days after the application or, in cases where bolls were only 15 days old at time of chemical application, the growth cessation did not occur until about the 19th or 20th day, or after fiber elongation has essentially ceased.

Protein (measured as ammonia) content of seed was not influenced by treatment with defoliants, even though the earliest treatments were applied during the period when protein was being rapidly elaborated in the seed. This lack of influence is caused in part by the percentage method of measuring, as less protein in the light, immature seed would be equivalent to more protein in the heavier and more mature seed. Also, it is known that, where seed reserves are lowered by environmental stresses, the accumulation of oil suffers proportionately more than the accumulation of protein—particularly when measured on a percentage-in-seed basis (14).

The evaluation of induced variation in spinning properties of fibers (table 23) shows two deleterious effects of premature defoliation: the increase in neps and the increase in waste. Both are a direct reflection of induced fiber fineness. These thin-walled fibers are a source of tangles and knots (neps) and are easily broken during processing; they thus contribute to waste at the mill.

Yield was decreased significantly in four of the nine tests wherein yield evaluations were made (table 23). These decreases, however, were brought about through reductions in only the late-harvested cotton. Actually, defoliation's effect on reducing yield can come about in three ways: Through curtailing the setting of new bolls, through reducing the number of seed per boll, and through reducing the weight of each seed and the lint per seed. Separation of yield reductions into these three component parts was not feasible in these studies.

From other studies (19), however, it has been established that when defoliants are applied as they were in these tests (not before 17 days after height of bloom or 15 days after cutout), the effect on reducing the set of additional bolls is negligible. Most yield losses come through a combination of reduced number of seed per boll and reduced weight (lint and seed) per seed. The number of seed per boll, which is determined very early during boll development (probably before the 10th day after blooming), can be of little importance in most of these tests, and it is the lowering of weight of seed and lint (collec-

tively this may be considered as lowered boll weight) that is predominantly reflected in the trends of defoliation effects on yield.

A final analysis of these combined data is made on the basis of what has happened to the early-harvested cotton—which could be affected little by defoliation—and the late-harvested cotton (table 24). Defoliation caused no consistent or sizable effect on yield and other properties of the early-harvested cotton from any of these tests. The deleterious effects were limited to the late-harvested cotton, which was in various stages of immaturity at the time the harvest-aid chemicals were applied.

Thus, those growers who plan to defoliate their cotton crop must be able to evaluate accurately the proportion of the crop that is still immature at the time of application. The safest approach would be never to defoliate until all bolls were mature. But this is not always possible or desirable, particularly when the grower finds he is losing value of a crop already made while waiting for maturity of the sometimes elusive top crop.

Results from these studies indicate that defoliant applied when cotton plants contain bolls at least 32 days old in the Southeast and 42 days old in the irrigated West (where varieties and climate contribute to a longer period of boll development) should cause no appreciable loss in yield or quality of lint and seed.

It should be cautioned that these recommendations are based on studies with defoliant, some of which act quickly and others rather slowly. Where desiccants are applied, boll growth ceases more quickly. The safe application time for desiccants would thus be about 3 to 5 days after it would be considered safe to apply defoliant.

SUMMARY

The effect of time of defoliation on cotton yield and properties of fiber and seed, determined from 11 tests in 5 States over a 3-year period, was primarily dependent upon the relative maturity of the crop at the time of defoliation.

Although there was considerable variation between one test and the next, results of these studies show:

1. Defoliation has no deleterious influence on bolls open or those fully mature and as yet unopened at the time of application.

2. Any boll less than 36 days old at time of defoliation may suffer loss in weight of fiber and seed and in quality of products; particularly oil content of seed and fineness of fibers. This "36 days of age" is an average value. Where boll periods are short the safe time for defoliant application will be earlier, about 32 days; and where long, as is usually the case in the irrigated Far West, the safe period will be about 42 days.

3. Defoliation prior to this safe period resulted in loss in yield and in quality of lint and seed in the following order:

- a. Yield of seed cotton—reduced;
- b. Oil content of seed—reduced;
- c. Fiber fineness—increased;
- d. Viability of seed—reduced;

- e. Pressley strength of fibers—occasionally increased;
 - f. Spinning value of yarns (increase in neps and waste, and decrease in yarn appearance grade but no change in skein strength)—reduced;
 - g. Upper half mean length of fibers—no change; and
 - h. Protein content of seed—no change.
4. The net loss in yield and quality of the total crop depended wholly on the proportion of the crop that was immature at the time of defoliation.

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APPENDIX

TABLE 1.—*Effect of time of defoliation on upper half mean length of cotton fibers at 4 locations, series A, 1948*

Harvest and time of defoliant application	Fiber length (U.H.M.) ¹ at—			
	Sacaton, Ariz.	Marianna, Ark.	Stoneville, Miss.	Sikeston, Mo.
Early (bottom crop): ²	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>
17 days after height of bloom.....	1.04	1.15	1.04	1.05
23 days after height of bloom.....	1.05	1.15	1.05	1.03
29 days after height of bloom.....	1.04	1.14	1.06	1.06
35 days after height of bloom.....	1.03	1.14	1.06	1.05
41 days after height of bloom.....	1.05	1.15	1.04	1.04
Check, not defoliated.....	1.05	1.14	1.05	1.05
Late (top crop): ³				
17 days after height of bloom.....	1.08	1.02	-----	.86
23 days after height of bloom.....	1.06	1.04	-----	.86
29 days after height of bloom.....	1.06	1.05	-----	.87
35 days after height of bloom.....	1.08	1.05	-----	.90
41 days after height of bloom.....	1.09	1.06	-----	.88
Check, not defoliated.....	1.09	1.04	-----	.90
Tagged bolls: ⁴				
17 days after height of bloom.....	1.06	1.01	1.03	.88
23 days after height of bloom.....	1.07	1.03	1.06	.91
29 days after height of bloom.....	1.07	1.00	1.07	.96
35 days after height of bloom.....	1.10	1.02	1.07	.92
41 days after height of bloom.....	1.09	1.02	-----	.92
Check, not defoliated.....	1.08	1.04	1.06	.96

¹ Mean differences in fiber length associated with time of defoliation were not found significant at the 5-percent level.

² Early cotton was picked when the tagged bolls were opening. It includes all the bolls set prior to height of bloom.

³ The late harvest includes the bolls set after height of bloom.

⁴ Open bolls were tagged on the day estimated as height of bloom.

TABLE 2.—*Effect of time of defoliation on upper half mean length of cotton fibers at 5 locations, series B*

Time of harvest and time of defoliant application	Fiber length (U.H.M.) ¹ at—						
	Sacaton, Ariz.		Marianna, Ark.	Stoneville, Miss.	Sikeston, Mo.		Chickasha, Okla.
	1949	1950	1949	1949	1949	1950	1949
Harvest 1 (15 days after cutout):	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>
Check (not defoliated).....	1.08	1.12	1.24	1.18	1.04	-----	-----
Harvest 2 (23 days after cutout):							
15 days after cutout.....	-----	-----	1.17	1.18	1.05	-----	1.01
Check (not defoliated).....	-----	-----	1.17	1.20	1.05	-----	.99
Harvest 3 (31 days after cutout):							
15 days after cutout.....	1.06	1.08	1.14	1.12	1.06	1.14	.98
23 days after cutout.....	-----	-----	1.16	1.14	1.07	1.14	.98
Check (not defoliated).....	1.09	1.08	1.14	1.19	1.09	1.12	.94
Harvest 4 (final):							
15 days after cutout.....	1.04	1.03	1.12	1.01	.91	1.03	.95
23 days after cutout.....	-----	-----	1.13	1.04	.99	1.14	.96
31 days after cutout.....	1.05	1.09	1.13	1.06	.96	1.05	.95
Check (not defoliated).....	1.04	1.12	1.08	1.07	.99	1.12	.90
Means for treatments:							
15 days after cutout.....	1.06	1.07	1.17	1.12	1.02	(²)	.98
23 days after cutout.....	-----	-----	1.18	1.14	1.06	(²)	.99
31 days after cutout.....	1.07	1.10	1.17	1.15	1.03	(²)	.97
Check (not defoliated).....	1.07	1.11	1.16	1.16	1.04	(²)	.94

¹ Differences between treatment means and undefoliated checks were not found significant at the 5-percent level.

² Fiber length data not sufficiently complete for evaluation of mean response to defoliant treatments.

TABLE 3.—Effect of time of defoliation on cotton fiber strength at 4 locations, series A, 1948

Harvest and time of defoliant application	Fiber strength (Pressley Index) at—			
	Sacaton, Ariz.	Marianna, Ark.	Stoneville, Miss.	Sikeston, Mo.
<i>Early (bottom crop):</i> ¹	<i>Index</i>	<i>Index</i>	<i>Index</i>	<i>Index</i>
17 days after height of bloom.....	6.74	6.83	6.97	7.08
23 days after height of bloom.....	6.72	6.77	6.89	6.91
29 days after height of bloom.....	6.76	6.87	6.93	6.98
35 days after height of bloom.....	6.71	6.88	6.85	6.80
41 days after height of bloom.....	6.69	6.93	-----	7.01
Check, not defoliated.....	6.70	7.03	6.92	6.96
<i>Late (top crop):</i> ²				
17 days after height of bloom.....	7.06	6.78	-----	7.23
23 days after height of bloom.....	7.12	6.67	-----	7.18
29 days after height of bloom.....	7.09	6.59	-----	7.12
35 days after height of bloom.....	6.95	6.72	-----	7.16
41 days after height of bloom.....	7.00	6.71	-----	7.15
Check, not defoliated.....	7.03	6.66	-----	7.02
<i>Tagged bolls (late):</i> ³				
17 days after height of bloom.....	7.10	7.16	7.24	7.42
23 days after height of bloom.....	7.22	6.86	7.19	7.36
29 days after height of bloom.....	7.27	6.84	7.21	7.32
35 days after height of bloom.....	7.19	6.77	6.95	7.37
41 days after height of bloom.....	7.14	6.83	-----	7.28
Check, not defoliated.....	7.08	6.77	6.94	7.24
L.S.D. 1-percent level.....	-----	.23	.23	.07
L.S.D. 5-percent level.....	-----	.32	-----	.10

¹ Early cotton was picked when the tagged bolls were opening. It includes all the bolls set prior to height of bloom.

² The late harvest includes the bolls set after height of bloom.

³ Open blooms were tagged on the day estimated as height of bloom.

TABLE 4.—Effect of time of defoliation on cotton fiber strength at 5 locations, series B¹

Time of harvest and time of defoliant application	Fiber strength (Pressley Index) at—						
	Sacaton, Ariz.		Marianna, Ark.	Stoneville, Miss.	Sikeston, Mo.		Chickasha, Okla.
	1949	1950	1949	1949	1949	1950	1949
<i>Harvest 1 (15 days after cutout):</i>	<i>Index</i>	<i>Index</i>	<i>Index</i>	<i>Index</i>	<i>Index</i>	<i>Index</i>	<i>Index</i>
Check, not defoliated.....	8.24	7.59	6.92	6.83	6.79	-----	-----
<i>Harvest 2 (23 days after cutout):</i>							
15 days after cutout.....	-----	-----	7.22	6.75	6.92	-----	7.80
Check, not defoliated.....	-----	-----	7.31	6.96	7.07	-----	7.80
<i>Harvest 3 (31 days after cutout):</i>							
15 days after cutout.....	7.42	7.84	7.06	7.13	7.34	6.11	7.36
23 days after cutout.....	-----	-----	7.02	7.10	7.12	6.64	7.50
Check, not defoliated.....	7.13	7.74	6.98	7.17	7.14	6.67	7.59
<i>Harvest 4 (final):</i>							
15 days after cutout.....	7.64	7.72	6.93	6.79	6.82	6.42	7.03
23 days after cutout.....	-----	-----	6.67	6.93	6.95	6.35	6.99
31 days after cutout.....	7.38	8.03	7.17	6.95	7.17	6.39	7.36
Check, not defoliated.....	7.16	7.83	6.91	6.91	6.77	6.59	7.15
<i>Means for treatments:</i>							
15 days after cutout.....	7.70	7.70	7.03	6.88	6.97	6.26	7.40
23 days after cutout.....	-----	-----	7.02	6.92	6.94	6.50	7.36
31 days after cutout.....	7.38	7.84	6.94	6.90	6.92	6.52	7.36
Check, not defoliated.....	7.68	7.72	7.03	6.97	6.94	6.63	7.51

¹ Differences between treatment means and undefoliated checks for cotton fiber strength were not found significant at the 5-percent level.

TABLE 5.—*Effect of time of defoliation on cotton fiber fineness at 3 locations, series A, 1948*

Harvest and time of defoliant application	Fiber fineness (surface area) at—		
	Sacaton, Ariz.	Marianna, Ark.	Stoneville, Miss.
Early (bottom crop): ¹	<i>Mm.</i> ² / <i>mm.</i> ³	<i>Mm.</i> ² / <i>mm.</i> ³	<i>Mm.</i> ² / <i>mm.</i> ³
17 days after height of bloom.....	441	517	444
23 days after height of bloom.....	441	501	420
29 days after height of bloom.....	438	494	398
35 days after height of bloom.....	437	478	390
41 days after height of bloom.....	439	479	-----
Check, not defoliated.....	444	470	398
L.S.D., 5-percent level.....	-----	20	33
L.S.D., 1-percent level.....	-----	27	46
Late (top crop): ²	-----	-----	-----
17 days after height of bloom.....	456	607	-----
23 days after height of bloom.....	469	583	-----
29 days after height of bloom.....	467	615	-----
35 days after height of bloom.....	478	556	-----
41 days after height of bloom.....	473	541	-----
Check, not defoliated.....	460	536	-----
L.S.D., 5-percent level.....	-----	26	-----
L.S.D., 1-percent level.....	-----	36	-----
Tagged bolls (late): ³	-----	-----	-----
17 days after height of bloom.....	473	(⁴)	559
23 days after height of bloom.....	471	529	590
29 days after height of bloom.....	456	530	491
35 days after height of bloom.....	422	527	436
41 days after height of bloom.....	417	516	-----
Check, not defoliated.....	432	530	406
L.S.D., 5-percent level.....	25	(⁴)	59
L.S.D., 1-percent level.....	34	-----	82

¹ Early cotton was picked when the tagged bolls were opening. It includes all the bolls set prior to height of bloom.

² The late harvest includes the bolls set after height of bloom.

³ Open blooms were tagged on the day estimated as height of bloom.

⁴ Fibers were too fine for measurement on the arealometer scale (over 800); undoubtedly significantly different from check.

TABLE 6.—*Effect of time of defoliation on cotton fiber fineness at 5 locations, series B*

Time of harvest and time of defoliant application	Fiber fineness (surface area) at—						
	Sacaton, Ariz.		Marianna, Ark.	Stoneville, Miss.	Sikeston, Mo.		Chickasha, Okla.
	1949	1950	1949	1949	1949	1950	1949
Harvest 1 (15 days after cut- out):	<i>Mm.</i> ² / <i>mm.</i> ³	<i>Mm.</i> ² / <i>mm.</i> ³	<i>Mm.</i> ² / <i>mm.</i> ³	<i>Mm.</i> ² / <i>mm.</i> ³	<i>Mm.</i> ² / <i>mm.</i> ³	<i>Mm.</i> ² / <i>mm.</i> ³	<i>Mm.</i> ² / <i>mm.</i> ³
Check, not defoliated.....	442	459	476	452	513	-----	-----
Harvest 2 (23 days after cutout):	-----	-----	-----	-----	-----	-----	-----
15 days after cutout.....	-----	-----	481	465	504	-----	398
Check, not defoliated.....	-----	-----	470	473	502	-----	406
Harvest 3 (31 days after cutout):	-----	-----	-----	-----	-----	-----	-----
15 days after cutout.....	476	498	522	518	501	485	409
23 days after cutout.....	-----	-----	491	507	500	455	392
Check, not defoliated.....	433	471	507	507	487	488	397
Harvest 4 (final):	-----	-----	-----	-----	-----	-----	-----
15 days after cutout.....	479	585	576	532	885	496	520
23 days after cutout.....	-----	-----	524	515	714	504	490
31 days after cutout.....	446	460	493	490	484	479	394
Check, not defoliated.....	443	468	507	466	550	474	461
Means for treatments:	-----	-----	-----	-----	-----	-----	-----
15 days after cutout.....	466	514	514	492	601	490	442
23 days after cutout.....	-----	-----	491	485	557	480	425
31 days after cutout.....	450	470	496	469	553	476	449
Check, not defoliated.....	439	466	490	474	513	481	421
L.S.D., 5-percent level.....	22	22	-----	-----	41	-----	-----
L.S.D., 1-percent level.....	-----	30	-----	-----	58	-----	-----

TABLE 7.—*Effect of time of defoliation on germination of cottonseed at 4 locations, series A, 1948*

Harvest and time of defoliant application	Germination at—			
	Sacaton, Ariz.	Marianna, Ark.	Stoneville, Miss.	Sikeston, Mo.
Early (bottom crop): ¹	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
17 days after height of bloom.....	94.5	93.5	87.5	89.0
23 days after height of bloom.....	95.6	96.0	91.5	89.0
29 days after height of bloom.....	96.4	91.5	91.0	91.0
35 days after height of bloom.....	96.6	93.0	95.5	91.0
41 days after height of bloom.....	95.2	98.0	-----	91.0
Check, not defoliated.....	94.2	94.0	93.0	92.0
L.S.D., 5-percent level.....	-----	-----	7.1	-----
Late (top crop): ²	-----	-----	-----	-----
17 days after height of bloom.....	80.5	85.5	-----	81.5
23 days after height of bloom.....	75.5	88.5	-----	80.8
29 days after height of bloom.....	75.0	85.5	-----	81.0
35 days after height of bloom.....	79.7	85.5	-----	79.0
41 days after height of bloom.....	70.0	93.5	-----	80.0
Check, not defoliated.....	82.0	92.5	-----	77.2
L.S.D., 5-percent level.....	-----	7.0	-----	-----
Tagged bolls (late): ³	-----	-----	-----	-----
17 days after height of bloom.....	95.7	83.5	83.0	86.0
23 days after height of bloom.....	96.5	87.5	74.5	89.0
29 days after height of bloom.....	96.2	88.5	95.0	87.0
35 days after height of bloom.....	96.5	89.5	97.0	89.0
41 days after height of bloom.....	97.1	95.0	-----	84.0
Check, not defoliated.....	97.1	96.5	97.0	89.5
L.S.D., 5-percent level.....	-----	8.4	6.4	-----
L.S.D., 1-percent level.....	-----	11.7	8.9	-----

¹ Early cotton was picked when the tagged bolls were opening. It includes all the bolls set prior to height of bloom.

² The late harvest includes the bolls set after height of bloom.

³ Open blooms were tagged on the day estimated as height of bloom.

TABLE 8.—*Effect of time of defoliation on germination of cottonseed at 5 locations, series B*

Time of harvest and time of defoliant application	Germination at—						
	Sacaton, Ariz.		Marianna, Ark.	Stoneville, Miss.	Sikeston, Mo.		Chickasha, Okla.
	1949	1950	1949	1949	1949	1950	1949
Harvest 1 (15 days after cutout):	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
Check, not defoliated.....	97	92	93	97	79	42	-----
Harvest 2 (23 days after cutout):	-----	-----	-----	-----	-----	-----	-----
15 days after cutout.....	-----	-----	93	97	85	48	-----
Check, not defoliated.....	-----	-----	95	97	81	45	-----
Harvest 3 (31 days after cutout):	-----	-----	-----	-----	-----	-----	-----
15 days after cutout.....	95	84	98	96	84	56	97
23 days after cutout.....	-----	-----	91	97	89	63	92
Check, not defoliated.....	91	96	85	96	87	64	92
Harvest 4 (final):	-----	-----	-----	-----	-----	-----	-----
15 days after cutout.....	90	91	70	84	46	54	98
23 days after cutout.....	-----	-----	83	89	76	76	94
31 days after cutout.....	94	90	85	89	84	79	97
Check, not defoliated.....	81	93	89	97	85	82	97
Means for treatments:	-----	-----	-----	-----	-----	-----	-----
15 days after cutout.....	94	91	86	94	74	50	98
23 days after cutout.....	-----	-----	90	96	82	58	93
31 days after cutout.....	96	93	90	95	82	53	95
Check, not defoliated.....	91	94	90	97	83	82	97
L.S.D., 5-percent level.....	-----	-----	4.1	-----	5.4	-----	-----
L.S.D., 1-percent level.....	-----	-----	-----	-----	7.7	(1)	-----

¹ Replicates were pooled to form adequate size sample for testing. Variance analysis not applicable.

TABLE 9.—*Effect of time of defoliation on the oil content of cottonseed at 4 locations, series A, 1948*

Harvest and time of defoliant application	Oil content of seed (percent in fuzzy seed) at—			
	Sacaton, Ariz.	Marianna, Ark.	Stoneville, Miss.	Sikeston, Mo.
Early (bottom crop): ¹	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
17 days after height of bloom.....	17.9	17.9	16.5	14.2
23 days after height of bloom.....	18.2	18.8	17.0	13.8
29 days after height of bloom.....	18.0	19.3	17.5	13.7
35 days after height of bloom.....	18.0	19.0	18.4	14.7
41 days after height of bloom.....	17.8	19.2	-----	14.5
Check, not defoliated.....	17.8	19.3	18.1	15.0
L.S.D., 5-percent level.....	-----	.77	.60	-----
L.S.D., 1-percent level.....	-----	1.06	.84	-----
Late (top crop): ²				
17 days after height of bloom.....	17.7	16.8	-----	10.9
23 days after height of bloom.....	17.4	17.9	-----	11.0
29 days after height of bloom.....	17.2	17.5	-----	11.5
35 days after height of bloom.....	17.2	18.2	-----	11.9
41 days after height of bloom.....	17.5	19.0	-----	11.2
Check, not defoliated.....	17.8	19.6	-----	13.2
L.S.D., 5-percent level.....	-----	2.6	-----	.51
L.S.D., 1-percent level.....	-----	-----	-----	.81
Tagged bolls (late): ³				
17 days after height of bloom.....	-----	15.2	-----	-----
23 days after height of bloom.....	-----	17.2	-----	-----
29 days after height of bloom.....	-----	16.6	-----	-----
35 days after height of bloom.....	-----	17.8	-----	-----
41 days after height of bloom.....	-----	18.0	-----	-----
Check, not defoliated.....	-----	18.2	-----	-----
L.S.D., 5-percent level.....	-----	.34	-----	-----
L.S.D., 1-percent level.....	-----	.54	-----	-----

¹ Early cotton was picked when the tagged bolls were opening. It includes all the bolls set prior to height of bloom.

² The late harvest includes the bolls set after height of bloom.

³ Open blooms were tagged on the day estimated as height of bloom.

TABLE 10.—*Effect of time of defoliation on oil content of cottonseed at 5 locations, series B*

Time of harvest and time of defoliant application	Oil content of seed (percent in fuzzy seed) at—						
	Sacaton, Ariz.		Marianna, Ark.	Stoneville Miss.	Sikeston, Mo.		Chickasha, Okla.
	1949	1950	1949	1949	1949	1950	1949
Harvest 1 (15 days after cutout):	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
Check, not defoliated.....	18.1	20.0	21.2	20.0	17.5	18.9	-----
Harvest 2 (23 days after cutout):							
15 days after cutout.....	-----	-----	20.6	19.4	17.1	20.2	-----
Check, not defoliated.....	-----	-----	21.3	19.1	18.0	20.2	-----
Harvest 3 (31 days after cutout):							
15 days after cutout.....	17.3	19.6	19.4	17.2	17.2	19.2	18.1
23 days after cutout.....	-----	-----	20.4	18.0	17.8	19.9	18.4
Check, not defoliated.....	18.1	20.0	21.0	18.2	19.0	20.0	18.5
Harvest 4 (final):							
15 days after cutout.....	16.6	17.2	15.7	17.8	16.0	16.8	16.0
23 days after cutout.....	-----	-----	18.2	17.9	17.7	19.8	16.4
31 days after cutout.....	17.1	19.6	18.8	19.0	18.5	20.0	17.8
Check, not defoliated.....	18.2	19.8	19.6	19.4	19.5	19.8	18.0
Means for treatments:							
15 days after cutout.....	17.4	19.0	19.2	18.6	17.0	18.2	17.0
23 days after cutout.....	-----	-----	20.1	18.8	17.9	19.5	17.4
31 days after cutout.....	17.8	20.0	20.4	19.5	18.2	19.7	18.2
Check, not defoliated.....	18.1	20.2	20.8	19.2	18.5	19.8	18.2
L.S.D., 5-percent level.....	.61	-----	.59	-----	.43	-----	.54
L.S.D., 1-percent level.....	-----	-----	.85	-----	.62	-----	.79

TABLE 11.—*Effect of time of defoliation on spinning properties of selected samples from tests at 4 locations, series A, 1948*¹

Location, variety, and time of defoliation	Spinning properties of carded yarns					
	Skein strength			Yarn appearance grade	Neps in 100 inches of card web	Picker and card waste
	22s	36s	50s			
	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Grade</i>	<i>Number</i>	<i>Percent</i>
Sacaton, Ariz. (Acala Santan):						
17 days after height of bloom.....	119.0	66.2	42.6	6.0 (B—)	23	8.8
29 days after height of bloom.....	120.0	66.2	41.9	5.6 (C+)	18	8.8
Check, not defoliated.....	120.3	66.2	41.8	6.4 (C+)	18	8.8
Marianna, Ark. (Arkot 2-1):						
17 days after height of bloom.....	121.4	67.1	43.3	5.6 (B—)	9	9.9
29 days after height of bloom.....	119.2	64.1	42.2	6.3 (B—)	9	10.6
Check, not defoliated.....	120.5	66.8	43.1	5.6 (B—)	12	9.2
Stoneville, Miss. (Deltapine 15):						
17 days after height of bloom.....	119.3	66.7	41.0	6.6 (C+)	29	8.8
20 days after height of bloom.....	114.1	61.8	39.0	5.6 (B—)	17	7.9
Check, not defoliated.....	114.2	61.3	40.2	5.6 (B—)	16	9.1
Sikeston, Mo. (Paula):						
17 days after height of bloom.....	128.2	69.9	44.6	7.6 (C)	43	9.6
26 days after height of bloom.....	127.7	70.5	46.3	6.3 (B—)	31	10.6
Check, not defoliated.....	130.7	72.1	45.6	6.6 (C+)	25	11.2

¹ Because the cotton from all replications and harvests of each treatment was blended to form a sample of adequate size for the spinning test, the data are not subject to statistical evaluation.

TABLE 12.—*Effect of time of defoliation on spinning properties of carded yarns, Acala 44 cotton, Sacaton, Ariz., series B*

Year, time of harvest, and time of defoliation	Spinning properties of carded yarns					
	Skein strength			Yarn appearance grade	Neps in 100 inches of card web	Picker and card waste
	22s	36s	50s			
	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Grade</i>	<i>Number</i>	<i>Percent</i>
1949:						
Harvest 1 (15 days after cutout):						
Check, not defoliated.....	120	67	41	7 (C)	24	8.9
Harvest 2 (31 days after cutout):						
15 days after cutout.....	116	66	40	8 (C)	45	10.1
Check, not defoliated.....	112	65	40	7 (C+)	30	9.9
Harvest 3 (83 days after cutout):						
15 days after cutout.....	108	61	38	9 (C—)	56	10.1
31 days after cutout.....	109	61	37	8 (C)	26	9.9
Check, not defoliated.....	110	63	38	7 (C+)	27	10.0
1950:						
Harvest 1 (35 days after cutout):						
15 days after cutout.....	124	68	45	7 (C+)	25	8.2
Check, not defoliated.....	123	70	46	6 (B—)	21	8.1
Harvest 2 (59 days after cutout):						
15 days after cutout.....	126	66	45	7 (C+)	25	7.9
39 days after cutout.....	126	67	45	7 (C+)	24	7.1
Check, not defoliated.....	124	67	44	7 (C+)	19	8.5
Harvest 3 (final):						
15 days after cutout.....	117	64	43	(¹)	91	9.0
39 days after cutout.....	122	65	43	8 (C)	35	8.4
Check, not defoliated.....	121	65	43	6 (B—)	22	8.2

¹ Below grade.

TABLE 13.—*Effect of time of defoliation on spinning properties of carded yarns, Delfos 651 cotton, Marianna, Ark., series B, 1949*

Time of harvest and time of defoliation	Spinning properties of carded yarns					
	Skein strength			Yarn appearance grade	Neps in 100 inches of card web	Picker and card waste
	22s	36s	50s			
Harvest 1 (15 days after cutout):	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Grade</i>	<i>Number</i>	<i>Percent</i>
Check, not defoliated.....	119	71	42	7 (C+)	22	7.4
Harvest 2 (23 days after cutout):						
15 days after cutout.....	118	70	42	7 (C+)	15	7.6
Check, not defoliated.....	115	66	41	7 (C+)	16	6.5
Harvest 3 (31 days after cutout):						
15 days after cutout.....	119	68	42	7 (C+)	23	8.6
23 days after cutout.....	119	68	42	7 (C+)	27	7.6
Check, not defoliated.....	117	67	41	7 (C+)	23	8.1
Harvest 4 (final):						
15 days after cutout.....	102	58	36	10 (D+)	148	12.1
23 days after cutout.....	107	61	37	8 (C)	57	10.3
31 days after cutout.....	101	58	36	8 (C)	46	9.5
Check, not defoliated.....	102	60	36	8 (C)	23	9.0

TABLE 14.—*Effect of time of defoliation on spinning properties of carded yarns, Delfos 9169 cotton, Stoneville, Miss., series B, 1949*

Time of harvest and time of defoliation	Spinning properties of carded yarns					
	Skein strength			Yarn appearance grade	Neps in 100 inches of card web	Picker and card waste
	22s	36s	50s			
Harvest 1 (15 days after cutout):	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Grade</i>	<i>Number</i>	<i>Percent</i>
Check, not defoliated.....	125	72	46	5 (B)	26	6.8
Harvest 2 (23 days after cutout):						
15 days after cutout.....	129	73	47	7 (C+)	25	7.5
Check, not defoliated.....	129	73	48	7 (C+)	25	7.2
Harvest 3 (31 days after cutout):						
15 days after cutout.....	125	71	46	7 (C+)	29	7.8
23 days after cutout.....	126	71	44	7 (C+)	30	7.3
Check, not defoliated.....	124	72	45	7 (C+)	34	7.5
Harvest 4 (final):						
15 days after cutout.....	111	60	39	7 (C+)	47	12.1
23 days after cutout.....	108	60	37	8 (C)	68	12.2
31 days after cutout.....	103	57	36	7 (C+)	29	11.8
Check, not defoliated.....	105	58	35	7 (C+)	45	11.6

TABLE 15.—*Effect of time of defoliation on spinning properties of carded yarns, Paula cotton, Sikeston, Mo., series B, 1949*

Time of harvest and time of defoliation	Spinning properties of carded yarns					
	Skein strength			Yarn appearance grade	Neps in 100 inches of card web	Picker and card waste
	22s	36s	50s			
Harvest 1 (15 days after cutout):	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Grade</i>	<i>Number</i>	<i>Percent</i>
Check, not defoliated.....	105	60	37	8 (C)	55	10.1
Harvest 2 (23 days after cutout):						
15 days after cutout.....	114	63	40	8 (C)	46	8.4
Check, not defoliated.....	101	57	36	7 (C+)	25	11.5
Harvest 3 (31 days after cutout):						
15 days after cutout.....	102	59	36	8 (C)	56	10.4
23 days after cutout.....	99	58	35	7 (C+)	27	9.3
Check, not defoliated.....	95	56	35	7 (C+)	29	10.3
Harvest 4 (final):						
15 days after cutout.....	104	56	35	10 (D+)	104	12.0
23 days after cutout.....	104	57	35	8 (C+)	94	10.7
31 days after cutout.....	103	58	37	5 (B)	12	9.5
Check, not defoliated.....	97	57	33	7 (C+)	11	9.7

TABLE 16.—*Effect of time of defoliation on spinning properties of carded yarns, Paula cotton, Sikeston, Mo., series B, 1950*

Time of harvest and time of defoliation ¹	Spinning properties of carded yarns					
	Skein strength			Yarn appearance grade	Neps in 100 inches of card web	Picker and card waste
	22s	36s	50s			
Harvest 3 (31 days after cutout):	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Grade</i>	<i>Number</i>	<i>Percent</i>
15 days after cutout.....	93	49	31	6 (B-)	15	8.7
23 days after cutout.....	86	45	29	7 (C+)	14	9.4
Check, not defoliated.....	98	49	30	6 (B-)	8	8.2
Harvest 4 (50 days after cutout):						
15 days after cutout.....	98	53	36	7 (C+)	21	7.9
23 days after cutout.....	105	61	38	6 (B-)	14	6.2
31 days after cutout.....	107	60	38	6 (B-)	11	6.8
Check, not defoliated.....	105	59	37	7 (C+)	17	6.7
Harvest 5 (final):						
15 days after cutout ²	98	53	34	9 (D-)	33	8.5
23 days after cutout.....	104	56	37	8 (C)	34	9.4
Check, not defoliated.....	100	55	35	7 (C+)	19	9.0

¹ Plot samples at harvests 1 and 2 too small for spinning tests.² Samples from these plots too small for testing.

TABLE 17.—*Effect of time of defoliation on yield of seed cotton at two locations, series A, 1948*¹

Time of defoliant application	Yield (all harvests) of seed cotton at—			
	Sacaton, Ariz.		Sikeston, Mo.	
	Weight	Percentage of check	Weight	Percentage of check
	<i>Pounds</i>	<i>Percent</i>	<i>Pounds</i>	<i>Percent</i>
17 days after height of bloom.....	25.06	102.3	13.80	71.1
23 days after height of bloom.....	25.38	103.6	15.03	77.5
29 days after height of bloom.....	24.37	99.5	16.66	85.9
35 days after height of bloom.....	25.36	104.4	17.43	89.8
41 days after height of bloom.....	25.72	105.0	18.52	95.5
Check, not defoliated.....	24.49	100.0	19.40	100.0
L.S.D., 5-percent level.....	-----	-----	2.38	-----
L.S.D., 1-percent level.....	-----	-----	3.31	-----

¹ Yields were not recorded for the other 2 series A tests, at Marianna, Ark., and Stoneville, Miss.

TABLE 18.—*Effect of time of defoliation on yield of Acala 44 cotton, Sacaton, Ariz., series B, 1949-50*

Time of harvest and time of defoliation	Yield of seed cotton, first year			Yield of seed cotton, second year		
	Weight	Percentage of check		Weight per plot	Percentage of check	
		At each harvest	For each treatment		At each harvest	For each treatment
Harvest 1 (15 days after cutout):	<i>Pounds</i>	<i>Percent</i>	<i>Percent</i>	<i>Pounds</i>	<i>Percent</i>	<i>Percent</i>
15 days after cutout.....	-----	-----	-----	142	92.8	-----
31 days after cutout.....	-----	-----	-----	145	94.8	-----
Check, not defoliated.....	1 392	-----	-----	153	-----	-----
Harvest 2 (31 days after cutout):	-----	-----	-----	-----	-----	-----
15 days after cutout.....	489	98.7	-----	108	103.8	-----
31 days after cutout.....	498	100.6	-----	102	98.1	-----
Check, not defoliated.....	495	-----	-----	104	-----	-----
Harvest 3 (final):	-----	-----	-----	-----	-----	-----
15 days after cutout.....	164	36.4	-----	26	44.0	-----
31 days after cutout.....	431	95.8	-----	57	96.6	-----
Check, not defoliated.....	450	-----	-----	59	-----	-----
Total yields, all harvests:	-----	-----	-----	-----	-----	-----
15 days after cutout.....	1,045	-----	78.2	276	-----	87.3
31 days after cutout.....	1,321	-----	98.8	304	-----	96.2
Check, not defoliated.....	1,337	-----	100.0	316	-----	100.0
L.S.D., 5-percent level.....	-----	-----	-----	21.8	-----	-----
L.S.D., 1-percent level.....	-----	-----	-----	30.0	-----	-----

¹ Treatments pooled for first harvest (all picked prior to defoliation).

TABLE 19.—*Effect of time of defoliation on yield of Delfos 651 cotton, Marianna, Ark., series B, 1949*

Time of harvest and time of defoliation	Yield of seed cotton		
	Weight per plot	Percentage of check	
		At each harvest	For each treatment
Harvest 1 (15 days after cutout):	<i>Pounds</i>	<i>Percent</i>	<i>Percent</i>
Check, not defoliated.....	¹ 0.93	-----	-----
Harvest 2 (23 days after cutout):			
15 days after cutout.....	5.95	103	-----
23 days after cutout.....	3.65	83	-----
31 days after cutout.....	4.85	64	-----
Check, not defoliated.....	5.80	-----	-----
Harvest 3 (31 days after cutout):			
15 days after cutout.....	7.92	82	-----
23 days after cutout.....	10.45	109	-----
31 days after cutout.....	8.88	91	-----
Check, not defoliated.....	9.62	-----	-----
Harvest 4 (final):			
15 days after cutout.....	7.40	88	-----
23 days after cutout.....	11.00	131	-----
31 days after cutout.....	8.13	97	-----
Check, not defoliated.....	8.42	-----	-----
Total yields (all harvests):			
15 days after cutout.....	22.20	-----	90
23 days after cutout.....	26.03	-----	105
31 days after cutout.....	22.79	-----	92
Check, not defoliated.....	² 24.77	-----	100

¹ All plots untreated at harvest 1. Figure shown is average for all plots.² Yields for treatments not significantly different from checks at the 5-percent level.TABLE 20.—*Effect of time of defoliation on yield of Delfos 9169 cotton, Stoneville, Miss., series B, 1949*

Time of harvest and time of defoliation	Yield of seed cotton		
	Weight per plot	Percentage of check	
		At each harvest	For each treatment
Harvest 1 (15 days after cutout):	<i>Pounds</i>	<i>Percent</i>	<i>Percent</i>
Check, not defoliated.....	¹ 415	-----	-----
Harvest 2 (23 days after cutout):			
15 days after cutout.....	512	97	-----
23 days after cutout.....	533	101	-----
31 days after cutout.....	506	96	-----
Check, not defoliated.....	526	-----	-----
Harvest 3 (31 days after cutout):			
15 days after cutout.....	611	95	-----
23 days after cutout.....	586	91	-----
31 days after cutout.....	619	97	-----
Check, not defoliated.....	641	-----	-----
Harvest 4 (final):			
15 days after cutout.....	516	79	-----
23 days after cutout.....	454	70	-----
31 days after cutout.....	638	98	-----
Check, not defoliated.....	650	-----	-----
Total yields (all harvests):			
15 days after cutout.....	2,054	-----	91.2
23 days after cutout.....	1,988	-----	80.3
31 days after cutout.....	2,178	-----	97.9
Check, not defoliated.....	² 2,232	-----	100.0

¹ Average of all plots at first harvest. None treated prior to harvest.² Yields for treatments not significantly different from check at the 5-percent level.

TABLE 21.—*Effect of time of defoliation on yield of Paula cotton, Sikeston, Mo., series B, 1949-50*

Time of harvest and time of defoliation	Yield of seed cotton, first year			Yield of seed cotton, second year		
	Weight per plot	Percentage of check		Weight per plot	Percentage of check	
		At each harvest	For each treatment		At each harvest	For each treatment
Harvest 1 (15 days after cutout):	<i>Pounds</i>	<i>Percent</i>	<i>Percent</i>	<i>Pounds</i>	<i>Percent</i>	<i>Percent</i>
Check, not defoliated.....	¹ 1.5	-----	-----	¹ 1.3	-----	-----
Harvest 2 (23 days after cutout):						
15 days after cutout.....	5.6	140	-----	10.3	239	-----
23 days after cutout.....	4.2	110	-----	3.6	84	-----
31 days after cutout.....	3.9	98	-----	4.0	-----	-----
Check, not defoliated.....	4.0	-----	-----	4.3	-----	-----
Harvest 3 (31 days after cutout):						
15 days after cutout.....	6.5	151	-----	23.0	168	-----
23 days after cutout.....	5.8	135	-----	17.6	128	-----
31 days after cutout.....	4.5	105	-----	11.0	80	-----
Check, not defoliated.....	4.3	-----	-----	13.7	-----	-----
Harvest 4 (50 days after cutout):						
15 days after cutout.....	10.5	47	-----	21.4	64	-----
23 days after cutout.....	16.3	73	-----	32.4	97	-----
31 days after cutout.....	20.4	91	-----	31.8	95	-----
Check, not defoliated.....	22.0	-----	-----	33.3	-----	-----
Harvest 5 (final):						
15 days after cutout.....	-----	-----	-----	10.3	30	-----
23 days after cutout.....	-----	-----	-----	25.9	77	-----
31 days after cutout.....	-----	-----	-----	32.7	97	-----
Check, not defoliated.....	-----	-----	-----	33.8	-----	-----
Total yield (all harvests):						
15 days after cutout.....	24.1	-----	75.8	66.3	-----	76.7
23 days after cutout.....	27.8	-----	87.4	80.8	-----	93.5
31 days after cutout.....	30.3	-----	95.3	80.8	-----	93.5
Check, not defoliated.....	31.8	-----	100.0	86.4	-----	100.0
L.S.D., 5-percent level.....	5.4	-----	-----	59.4	-----	-----
L.S.D., 1-percent level.....	7.3	-----	-----	85.4	-----	-----

¹ Treatments pooled for first harvest—all picked prior to defoliation.TABLE 22.—*Effect of time of defoliation on yield of Stoneville 62 cotton, Chickasha, Okla., series B, 1949*

Time of harvest and time of defoliation	Yield of seed cotton		
	Weight per plot	Percentage of check	
		At each harvest	For each treatment
Harvest 1 (15 days after cutout):	<i>Pounds</i>	<i>Percent</i>	<i>Percent</i>
Harvest 2 (23 days after cutout):	(¹)	-----	-----
15 days after cutout.....	0.72	135	-----
23 days after cutout.....	.61	114	-----
31 days after cutout.....	.88	165	-----
Check, not defoliated.....	.54	-----	-----
Harvest 3 (31 days after cutout):			
15 days after cutout.....	3.12	108	-----
23 days after cutout.....	3.56	123	-----
31 days after cutout.....	3.52	122	-----
Check, not defoliated.....	2.89	-----	-----
Harvest 4 (final):			
15 days after cutout.....	13.51	83	-----
23 days after cutout.....	14.62	90	-----
31 days after cutout.....	13.59	84	-----
Check, not defoliated.....	16.22	-----	-----
Total yields (all harvests):			
15 days after cutout.....	17.33	-----	88.2
23 days after cutout.....	18.79	-----	95.6
31 days after cutout.....	17.99	-----	91.6
Check, not defoliated.....	² 19.65	-----	100.0

¹ No cotton picked on this date.² Yields for treatments not significantly different from checks at the 5-percent level.

TABLE 23.—*Changes in properties induced by premature defoliation of cotton; showing trends*

[+=increase, -=decrease, 0=no change; and significance of change—*=significant at 5-percent level and **=significant at 1-percent level]

Test location, series, and year	Induced changes caused by premature defoliation										Yield
	Fiber properties			Seed properties			Spinning performance ¹				
	Length (U.H.M.)	Strength (Pressley Index)	Fineness (surface area)	Germina- tion	Oil content	Ammonia content	Skein strength	Grade	Neps	Waste	
Sacaton, Ariz., A.....	-	+	+	-	+	+	+	+	+	+	+
Marianna, Ark., A.....	-	+	+	-	+	+	+	+	+	+	+
Stoneville, Miss., A.....	-	+	+	-	+	+	+	+	+	+	(2)
Sikeston, Mo., A.....	-	+	+	-	+	+	+	+	+	+	(2)
Sacaton, Ariz., B, 1949.....	-	+	+	+	-	+	-	-	+	+	-
Sacaton, Ariz., B, 1950.....	-	+	+	+	-	+	-	-	+	+	-
Marianna, Ark., B, 1949.....	+	+	+	-	-	+	+	0	+	+	+
Stoneville, Miss., B, 1949.....	+	+	+	-	-	+	+	0	+	+	+
Sikeston, Mo., B, 1949.....	+	+	+	-	-	+	+	0	+	+	+
Sikeston, Mo., B, 1950.....	+	+	+	-	-	+	+	0	+	+	+
Chickasha, Okla., B, 1949.....	+	-	+	+	-	+	+	0	+	+	+

¹ Replicates pooled. Statistical analysis not possible.² Yield data were not obtained in these tests.³ Fibers too fine for Aerolometer evaluation.TABLE 24.—*Changes in properties induced by premature defoliation in the early-harvested as compared to the late-harvested cotton, 1948-50*

[+=increase, -=decrease, 0=no change]

Test location, series, and year	Induced changes in early-harvested cotton									
	Fiber properties			Seed properties		Spinning performance				Yield
	Length	Strength	Fineness	Germination	Oil content	Skein strength	Grade	Neps	Waste	
Sacaton, Ariz., A.....	0	+	-	+	+	(((((
Marianna, Ark., A.....	+	+	+	+	+	(((((
Stoneville, Miss., A.....	+	+	+	+	+	(((((
Sikeston, Mo., A.....	+	+	+	+	+	(((((
Sacaton, Ariz., B, 1949.....	+	+	+	+	+	+	+	+	0	0
Sacaton, Ariz., B, 1950.....	+	+	+	+	+	+	+	+	+	+
Marianna, Ark., B, 1949.....	+	+	+	+	+	+	0	+	+	+
Stoneville, Miss., B, 1949.....	+	+	+	0	+	0	0	+	+	+
Sikeston, Mo., B, 1949.....	+	+	+	+	+	+	0	+	+	+
Sikeston, Mo., B, 1950.....	+	+	+	+	0	+	0	+	+	+
Chickasha, Okla., B, 1949.....	+	+	+	+	+	+	0	+	+	+

Test location, series, and year	Induced changes in late-harvested cotton									Yield
	Fiber properties			Seed prop- erties		Spinning performance				
	Length	Strength	Fineness	Germina- tion	Oil content	Skein strength	Grade	Neps	Waste	
Sacaton, Ariz., A.....	+	+	+	+	+	0	0	0	0	0
Marianna, Ark., A.....	+	+	+	+	+	0	0	0	0	0
Stoneville, Miss., A.....	+	+	+	+	+	0	0	0	0	0
Sikeston, Mo., A.....	+	+	0	+	+	0	0	0	0	0
Sacaton, Ariz., B, 1949.....	+	+	+	+	+	+	+	+	0	+
Sacaton, Ariz., B, 1950.....	+	+	+	+	+	+	0	+	+	+
Marianna, Ark., B, 1949.....	+	+	+	+	+	+	+	+	+	+
Stoneville, Miss., B, 1949.....	+	+	+	+	+	+	0	+	+	+
Sikeston, Mo., B, 1949.....	+	+	+	+	+	+	+	+	+	+
Sikeston, Mo., B, 1950.....	+	+	+	+	+	+	+	+	+	+
Chickasha, Okla., B, 1949.....	+	+	+	+	+	+	0	+	+	+

¹ Data were not obtained.